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BIOLOGY
HIGHER LEVEL
PAPER 3

Candidate session number

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Thursday 19 May 2011 (morning)

1 hour 15 minutes

Examination code

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INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options.
- Write your answers in the boxes provided.

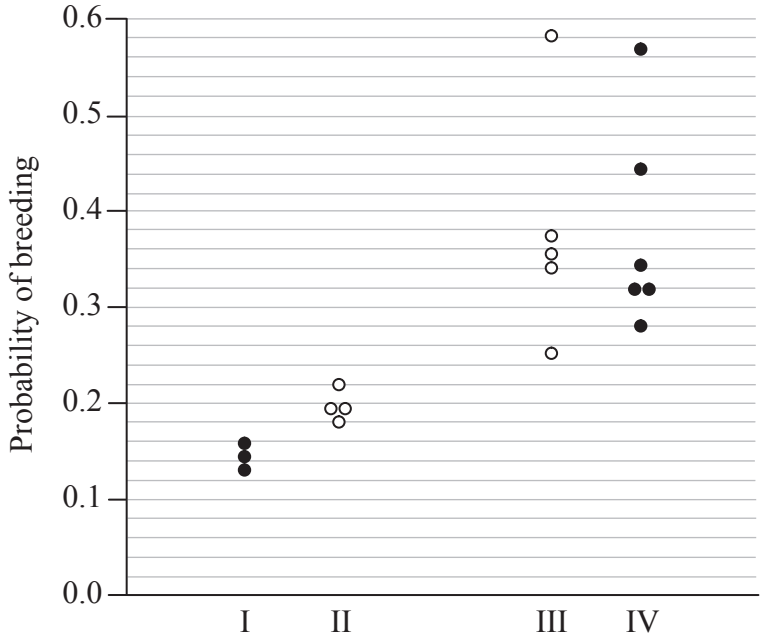
0132

Option D — Evolution

D1. Populations of threespine sticklebacks (*Gasterosteus* sp.), a fish living in small freshwater lakes in British Columbia, Canada, are derived from the marine threespine stickleback (*Gasterosteus aculeatus*). In order to investigate the process of speciation in these populations, three small lakes were studied. Each lake contained two varieties of stickleback: a large, bottom-dwelling variety that fed on invertebrates near the shore and a small, plankton-eating variety that lived in the open water. The probability of breeding between pairs of individuals was measured under laboratory conditions in the following breeding combinations:

I different varieties (small × large) from the same lake
II different varieties from different lakes
III same variety (small × small) and (large × large) from different lakes
IV same variety from the same lake.

The data are summarized below.



[Source: H D Rundle, *et al*., (2000), *Science*, **287**, pages 306–308]
From H. D. Rundle et al. (2000) *Science*, 287, pp. 306–308. Reprinted with permission from AAAS.

(a) Identify the highest and lowest probabilities of breeding for individuals of the same variety from different lakes. *[1]*

Highest probability: . . . . . .

Lowest probability: . . . . . .

(This question continues on the following page)

(Question D1 continued)

(b) Identify the breeding combination that results in the lowest probability of breeding. *[1]*

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(c) Analyse the probability of breeding between individuals from the same lake. *[2]*

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(d) Scientists concluded that speciation is taking place in these populations. Discuss the evidence for speciation provided by the data. *[3]*

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D2. (a) Define the term *clade*. *[1]*

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(b) Distinguish between analogous and homologous structures, giving an example of each. *[2]*

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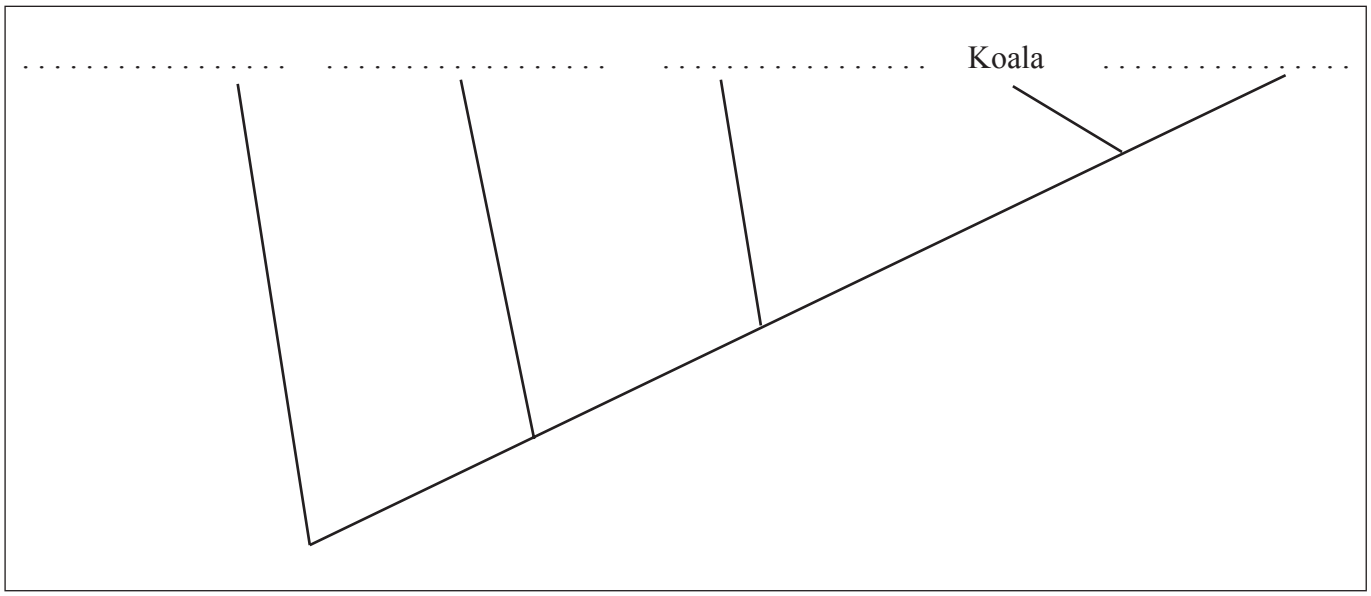
(Question D2 continued)

(c) The table below lists five animals along with four morphological characteristics. A plus sign (+) indicates that the animal has this characteristic while a minus sign (–) indicates that the characteristic is absent.

Animal	Jaws	Limbs	Hair	Placenta
Salamander	+	+	–	–
Mouse	+	+	+	+
Jellyfish	–	–	–	–
Koala	+	+	+	–
Salmon	+	–	–	–

Based on the features above, a student constructed a cladogram. State the names of the organisms missing in the following cladogram. *[2]*



(d) Describe the major anatomical features that define humans as primates. *[2]*

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D3. Discuss the endosymbiotic theory for the origin of eukaryotes. *[6]*

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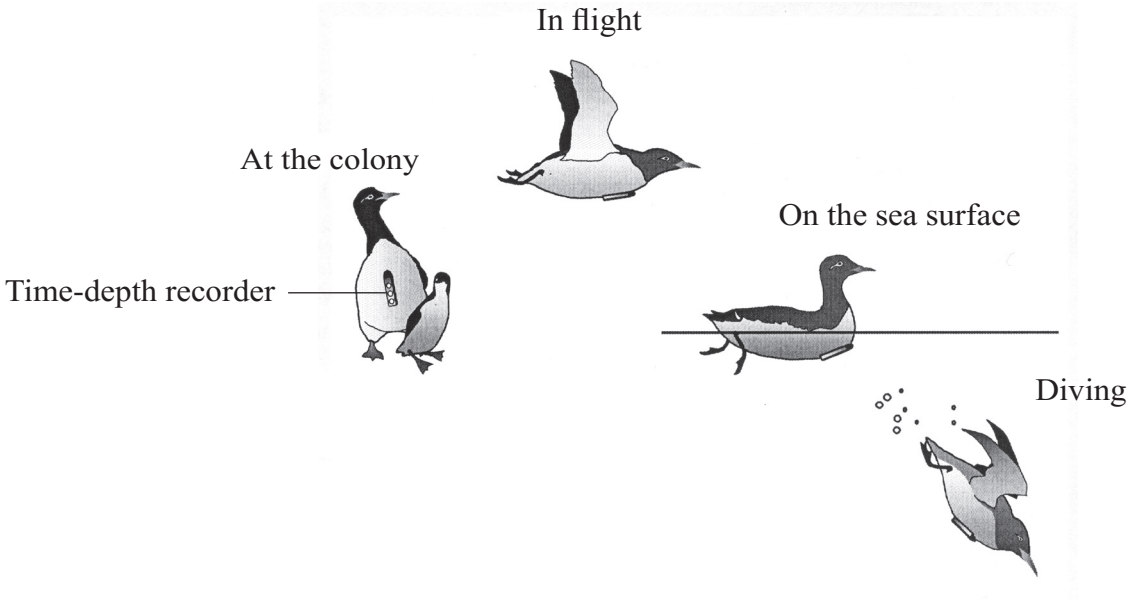
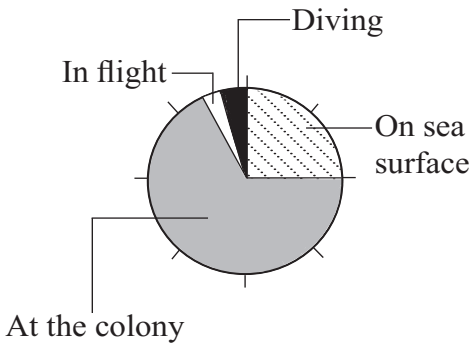
Answers written on this page
will not be marked.

Option E — Neurobiology and behaviour

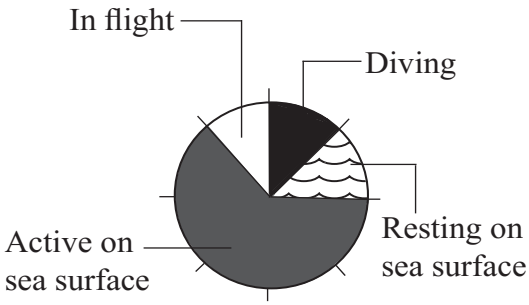
E1. Common guillemots (*Uria aalge*) are large sea birds of the auk family. They breed in colonies at high densities but make no nest. Their single egg is incubated on bare rock. Scientists fitted electronic time-depth recorders onto twelve common guillemots and recorded five different activities during the chick-rearing period: at the colony, in flight, resting or active on the sea surface and diving. The pie charts below include pooled data from all birds showing overall time budget and time budget at sea.



Overall time budget



Time budget at sea



[Source: Y Tremblay, *et al*., (2003), *The Journal of Experimental Biology*, **206**, pages 1929–1940]

(This question continues on the following page)

(Question E1 continued)

(a) State which activity takes up least of the overall time budget of the guillemots. *[1]*

. . . . . .

(b) Calculate the percentage of the overall time budget the guillemots spend resting on the sea surface. *[1]*

. . . . . %

(c) Alloparenting behaviour is frequently observed in guillemots. This is the process where non-breeding birds will take care of other chicks. Discuss the advantages of alloparenting behaviour. *[2]*

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(d) Suggest **one** reason, other than breeding, why birds spend more time at the colony than any other activity. *[1]*

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(This question continues on the following page)

(Question E1 continued)

(e) Making nests is an innate behaviour. Distinguish this type of behaviour from a learned behaviour. *[1]*

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E2. (a) Define the term *stimulus.* *[1]*

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(b) Outline the functions of the following parts of the brain.

(i) Medulla oblongata: *[1]*

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(ii) Hypothalamus: *[1]*

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(This question continues on the following page)

(Question E2 continued)

(c) Explain the effects of psychoactive drugs on synaptic transmission. *[3]*

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(d) Outline how endorphins act as painkillers. *[2]*

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E3. Explain how sound is perceived by the ear. *[6]*

Option F — Microbes and biotechnology

F1. Soy sauce contains many soluble compounds such as glucose, the amino acid tyrosine and soluble nitrogen compounds including urea, ammonium and nitrates. One of the most important steps in soy sauce production is the growth of *Aspergillus*. The strains of this mould that are used have high protease activity, no toxin production, and give a good taste and aroma to the final product. In factories several strains of mould are used, the most common are the different Japanese strains of *Aspergillus oryzae*. In Thailand, a locally occurring mould, *Aspergillus flavus*, is sometimes used. Several characteristics of the soy sauce produced using *Aspergillus flavus* were compared to those of soy sauce produced using *Aspergillus oryzae*. Acceptability was determined by factory workers based on aroma, colour and taste.

Soy sauce prepared from:	Protease activity / μm min^{-1} cm^{-3}	Tyrosine / g dm^{-3}	Soluble nitrogen / g dm^{-3}	Glucose / g dm^{-3}	Toxicity / aflatoxin bioassay	Acceptability
Aspergillus flavus						
After filtering	96	38.7	10.2	45.9	Not detectable	Acceptable
Aged	103	37.8	10.8	40.7	Not detectable	Acceptable
Aspergillus oryzae						
After filtering	64	22.9	4.7	32.1	Not detectable	Acceptable
Aged	126	28.2	4.9	35.4	Not detectable	Acceptable

A. Bhumiratana *et al*. (1980) *Applied and Environmental Microbiology*, 39, pp. 430–435.

(a) Calculate the percentage increase in protease activity in soy sauce prepared with *Aspergillus oryzae* when the soy sauce has been aged. *[1]*

(This question continues on the following page)

(Question F1 continued)

(b) Distinguish between the aged soy sauce produced by *Aspergillus flavus* and *Aspergillus oryzae.* *[2]*

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(c) Evaluate the use of the strain *Aspergillus flavus* in the production of soy sauce in Thailand. *[3]*

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F2. (a) Outline the diversity of Eubacteria according to cell wall structure. *[2]*

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(b) State the role of *Rhizobium* and *Nitrobacter* in the nitrogen cycle. *[2]*

Rhizobium: . . . . . .

Nitrobacter: . . . . . .

(c) Define the term *chemoautotroph.* *[2]*

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(d) Explain the use of bacteria in bioremediation. *[2]*

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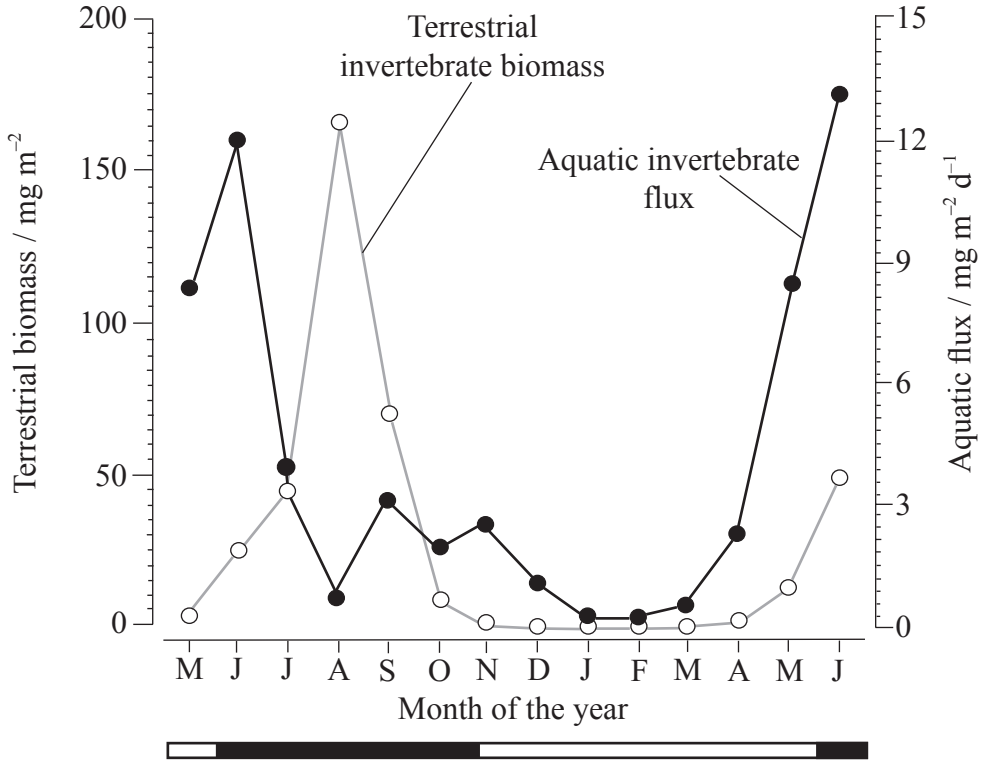
F3. Discuss the prion hypothesis for the cause of spongiform encephalopathies. *[6]*

Option G — Ecology and conservation

G1. The graph below shows the monthly mean values of terrestrial invertebrates from May 1997 to June 1998 in the northern hemisphere. The light line shows the biomass of invertebrates which are prey to forest birds (terrestrial invertebrate biomass). The darker line shows the invertebrates which lived in the stream and have moved to the forest (aquatic invertebrate flux or movement). The black bars on the horizontal line at the bottom show periods when trees have leaves and the white bars show periods of defoliation.



S. Nakano and M. Murakami, 'Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs'. *PNAS*, 98 (1) pp. 166-170. Figure 1C. Copyright (2001) National Academy of Sciences, U.S.A.

(a) State the mean terrestrial invertebrate biomass measured in August. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(b) Describe the trend in the aquatic invertebrate flux. *[2]*

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(c) Suggest the relationship between defoliation and the amount of terrestrial invertebrates in the forest. *[2]*

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(d) Suggest a possible explanation for the pattern in aquatic invertebrate flux to the forest seen between the months of June and December. *[2]*

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(This question continues on the following page)

(Question G1 continued)

(e) Allochthonous organisms are those which have migrated from one place to another, such as the aquatic invertebrates in this study. Suggest **one** effect of allochthonous invertebrates in this environment. *[1]*

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G2. (a) (i) State the name of the biome in which there is little precipitation and temperatures are very low. *[1]*

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(ii) Outline the characteristics of the vegetation of this biome. *[1]*

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(b) Outline the consequences of the edge effect for small nature reserves. *[2]*

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(c) Outline **one** example of biological control of invasive species. *[2]*

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G3. Some organisms have adopted *r*-strategies and some have adopted *K*-strategies. Discuss the environmental conditions that favour each of these strategies. *[6]*

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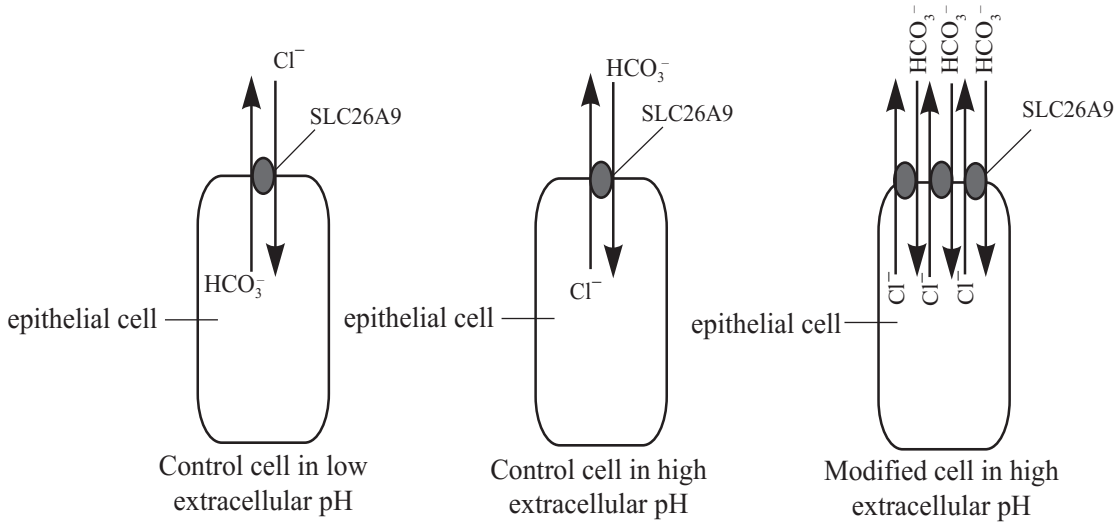
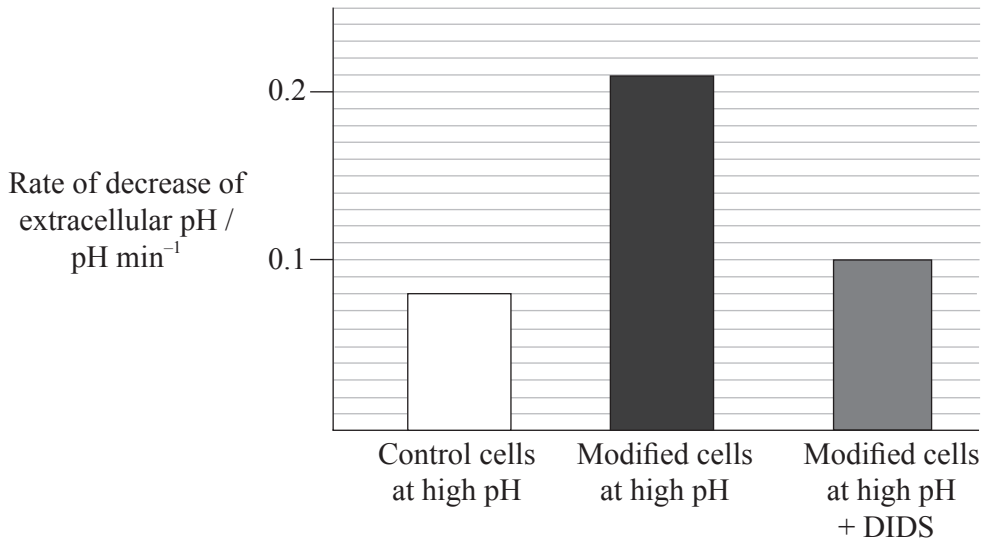
Option H — Further human physiology

H1. *Helicobacter pylori* infection is a cause of stomach ulcers. It affects SLC26A9, which is a membrane protein present in the epithelial lining of the stomach. SLC26A9 takes part in the reversible transport of chloride and hydrogen carbonate ions into and out of the epithelial cells in order to raise the pH at the membrane to neutral levels. Entry of chloride ions into epithelial cells and removal of hydrogen carbonate ions both cause extracellular pH to increase.

To assess the function of SLC26A9, this process was reversed by artificially raising the external pH. The rate of change of extracellular pH was measured with normal epithelial cells and with modified cells with extra SLC26A9. The tests were also performed in the presence of DIDS, an inhibitor of SLC26A9.





Reproduced with permission of the American Physiological Society from *American Journal of Physiology. Cell Physiology*, J. Xu et al., 289, pp. 493–505, 2005.

(This question continues on the following page)

(Question H1 continued)

(a) Calculate the difference in the rate of decrease of pH between the control cells and the modified cells without DIDS. *[1]*

. . . . . pH min^{-1}

(b) State the effect of DIDS on the rate of decrease of the extracellular pH. *[1]*

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(c) Scientists hypothesized that *Helicobacter pylori* alters the ability to maintain neutral pH at the epithelial cell surface by inhibition of SLC26A9. Evaluate this hypothesis. *[2]*

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(d) In further experiments, scientists observed that the levels of mRNA of SLC26A9 increased in epithelial cells when infected by *Helicobacter pylori*. Suggest a possible explanation for this increase. *[1]*

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(This question continues on the following page)

(Question H1 continued)

(e) Predict, with a reason, the effect of DIDS on stomach pH if given to an experimental subject. *[2]*

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H2. (a) Outline how coronary thrombosis can be caused. *[2]*

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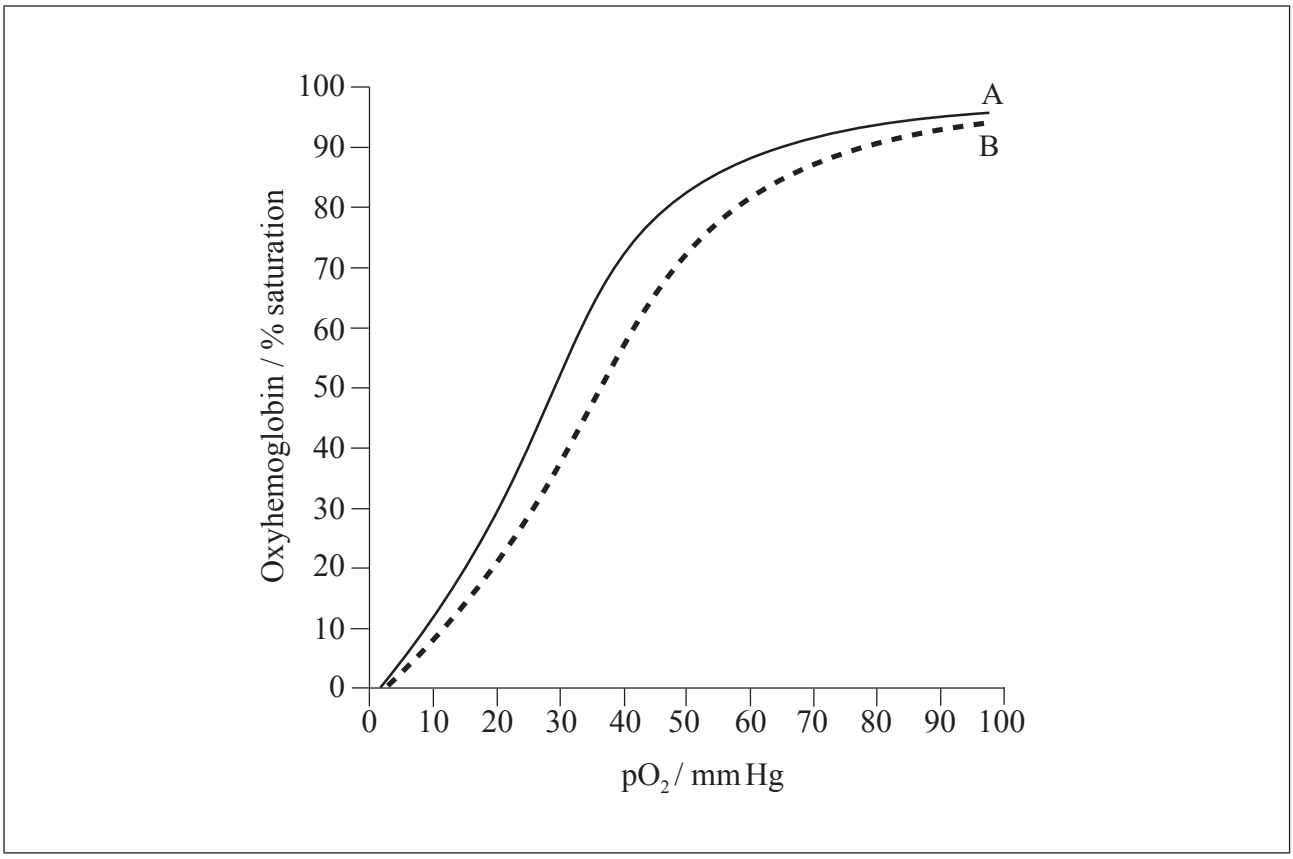
(Question H2 continued)

(b) The oxygen dissociation curve is a graph that shows the percentage saturation of hemoglobin at various partial pressures of oxygen. Curve A shows the dissociation at a pH of 7 and curve B shows the dissociation at a different pH.



(i) State the possible cause of the curve shifting from A to B. *[1]*

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(ii) On the graph, draw the curve for myoglobin. *[2]*

(This question continues on the following page)

(Question H2 continued)

(c) Describe the breakdown of hemoglobin in the liver. *[2]*

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H3. Explain the control of ADH secretion. *[6]*

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